embryo"; "The anatomical study of any plant (not at any one phase, but its anatomical development)"; etc. In addition to these attention should be called to the subjects suggested by Prof. Beal in his "New Botany" already referred to.

If any different ideas in the way of laboratory courses of study, or subjects for special work, can be called out by this article, the GAZETTE will be glad to give them room.

Section Cutting.

BY T. J. BURRILL.

Botanists as a whole seem to be far behind the zoologists in the matter of microscopical technic, especially in the preparation of material. Witness the literature upon injecting, staining, hardening, imbedding, infiltrating, fixing, cutting, handling, clearing—nearly all of it directly for or copied from the animal histologist.

No doubt this comes about naturally enough. In the first place animal tissues require a greater diversity of treatment, and to reach the highest results he who works especially upon them must have resources at command little dreamed of by those whose attention has been exclusively occupied with vegetable preparations. Then those who have earnestly worked upon the minute structure of plants are outnumbered many times by the skillful and intensely devoted animal histologist. The very fact that man's body is animal rather than plant, stimulates investigation on the former instead of the latter side.

But however it may be accounted for, botanists and vegetable physiologists, with only exceptions here and there, are much disposed to remain content with the early methods and processes which zoologists (perhaps zootomists is the word) now consider primitive and superseded. For myself I can not help feeling that I shall gain much by following, where I can not make better headway for my special purposes by special methods, the lead of my brothers, the animal histologists. Fixing my thought now upon simple work for the student botanical laboratory, I restrict myself to my theme. Nothing new is offered. What follows is simply some account of results from personal experience as student and instructor.

The first requisite for good section cutting is an *edge*. In a very large number of instances sections for microscopical study

can not be made too thin. Nothing but the keenest and smoothest edge will make the thinnest shavings. Among common and usually available articles a good razor furnishes the best edge. The form of the blade is also best, that is, some razors more nearly meet the requirements, so far as form of blade is concerned, than any other common knife. The requisites in a razor for this purpose may be put down as follows: (1) The material must be the best steel, suitably tempered; (2) the edge should be straight from toe to heel and free from "wind" and wabbles; (3) the blade should be of good width, the back firm and heavy and so shaped that in the process of honing the edge will remain straight; (4) both surfaces should be moderately hollow ground, the upper one by preference the most, but neither so much as to make the edge portion sensibly flexible; (5) the upper surface at least should be perfectly polished and free from engraving of any kind. Such razors, or nearly such, can be found in the usual markets and at reasonable cost; the highest priced ones are not commonly the best for our use.

For sharpening the best razor hone should be used. This latter must be perfectly level and free from gritty granules, and the blade must be held scrupulously flat. The best edge is secured by turning the razor at every stroke, after the usual manner, provided each stroke is accurate enough to always rest edge and back upon the stone. After honing until a perfectly true and keen edge is secured, finish upon a leather strop. The latter must be frequently used, but the usual artificial hones should be avoided.

Generally the operator will have to keep his own razor in order, and he can not be too careful about it. It will not do to trust the skill of the common barber in sharpening. Better study his own needs and then acquire the ability to meet them. An examination of the edge (held toward the light) with a magnifier will be instructive. The sharpened razor should never be used for anything besides cutting the thin sections. All preliminary whittling is to be done with another knife.

Having a proper *edge*, the next thing to be here considered is the manner of holding the object to be cut. For some purposes this can be sufficiently well done in the fingers, either by itself or between such substances as pith, cork, etc.; but in the better work contemplated in this description some form of a microtome is essential. Some persons become very expert by the free hand method, and all will do well to practice it at times, but all ought also to know that anyone, however expert, can make vastly better sections, at least for some and usually for most purposes, by the

use of a proper holding instrument. Undoubtedly the sliding microtome is the best form, and an object holder that grasps the material is better than one in which the latter is wedged or imbedded; but these are also much more expensive in construction than the ordinary "well" microtome with a screw for raising the object. For this reason my own laboratory is supplied with the latter form of instrument, each student having one clamped to his table. For special work resort is had to the better instruments.

There are, however, two important improvements upon the old well microtomes which can not be dispensed with without serious loss in efficiency. The first is a glass top, the second is a removable tube fitting the well. My instruments are made to order, and cost two and a half dollars each. They are, however, of iron; brass is better. Each is furnished with two or three brass tubes, in which the objects are placed, instead of putting the latter directly in the well itself. The tubes fit the well exactly, and are closed at bottom with a cork. This latter may be pushed up with the object and its holding material to the proper height before placing the tube in the well. The screw works on the tube, raising the whole together. In this way not only is imbedding much easier, but the certainty of the proper movement consequent upon turning the screw is far greater. There is always the same amount of friction to overcome and there is no elastic spring to interfere. The microtome must be fitted for clamping to the edge of the table.

The object to be cut is wedged more or less firmly in the well tube, according to the resistance offered to the knife. Delicate things may be put into pith, and by sloping the latter away so as to leave little of it to cut, the softest leaf or petal can be thus held sufficiently firm, without bruising. The latter is not nearly so likely to happen as when held in the fingers. Harder substances may be held by portions of velvet cork, this also being sloped properly away in a cone shaped top.

In numerous instances, however, some method of imbedding is greatly preferable to simple wedging in the tube holder. For this purpose there are many substances having special merits, and there is no one superior to others for all purposes. The nearest to this, however, for botanical uses is a soap mass, the only one to be herein described.

Take good, white hard soap ("Ivory" soap is excellent), cut in very thin slices, and having gently compressed them in a suitable dish, pour in enough 95 per cent. alcohol to somewhat more than cover the sliced soap. Heat to near the boiling point of the

alcohol until the soap is dissolved. Add now a small quantity of glycerine. The amount of the latter can be readily ascertained by pouring out a few drops of the warm mixture and allowing it to cool. Without any glycerine the mass instantly congeals into a white friable substance quite unfit for our purpose, but as a proportion is gradually added the mass hardens less and less rapidly and becomes more and more transparent. For soft tissues the imbedding mass may be thus made as transparent as glass and exquisite for cutting. For harder substances less glycerine must be used.

With this imbedding material fresh vegetable tissues need no preceding preparation, provided there is not a large amount of water in them, while substances preserved in alcohol are admirably adapted for immediate use. If infiltration is desired it is only necessary to keep the object some time in the warm mass. It is clean, and the instruments remain clean. The transparency enables one to see clearly the position of the object and to manage well the cutting. Thin sections are not so liable to roll up as with most other masses. It is readily soluble in water, but not in cold alcohol. In cutting it is better to keep the razor and the object wetted with the latter and transfer the sections to the former. If a well tube to imbed in is not at hand, pour the melted mass into any convenient dish or paper tray, immerse the object, and when the mass cools, cut it out and shape as required.

In cutting let the razor rest flat on the glass top of the microtome and *and hold it firmly with both hands.* Make a long draw or push stroke, so that a considerable portion of the edge of the razor is used each cut. See to it that there is not the least vibration of the blade by which the edge may be nicked. If everything is in order, and the handling properly done, it is surprising how hard substances may be cut without this last occurrence. We ought not to be satisfied until we can readily cut sections one-thousandth of an inch thick without tearing or bruising.

GENERAL NOTES.

Starch Grains.—Starch grains in the cells of potato can be beautifully shown by first partially drying the part from which sections are to be made, thereby aiding materially the process of cutting. Remove from a fresh tuber a prism one-fourth to one-half an inch in diameter and an inch or more in length. Expose for a few minutes to moderate heat (hot air from a register is excellent) until the *surfaces* are quite free from moisture, then allow to remain in the ordinary air of the laboratory for twenty-four hours. The consistence